

THE PIT-BUILDING ACTIVITIES OF OHIO ANT-LIONS

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The inverted conical pits built by ant-lions (the larvae of a neuropterous insect identified as *Myrmeleon immaculatus* De Geer) can be found in almost any loose friable soil that is sheltered somewhat from rain and wind. They are common in the soil of cave formations, the author having counted from 25 to 200 of them in such places as Cantwell Cliffs, Rock House, Ash Cave, Jacob's Ladder, or Old Man's Cave. Contradictory accounts of the pit-building behavior and ecology are found in the literature which was reviewed very completely by Wheeler (1930). Excluding the taxonomical studies of this form, very few articles can be found written by American scientists; these are mainly records of incidental observations with the major exception being the laboratory studies by Turner (1915). It is the purpose of the present author to submit field and laboratory data on pit-building with an endeavor to explain some of the discrepancies existing in the literature. He also wishes to take this opportunity to thank W. M. Barrows for his critical suggestions concerning this study.

CONSTRUCTION OF THE PIT

Field Observations. No ant-lions were seen starting the formation of the pits in their natural habitat. Several partial pits were observed in the midst of their construction, and in them the only visible part of the ant-lion was the head with its long mandibles. As the ant-lion moved backwards in an ever-deepening and narrowing circle, the rapid head-tossing movements resulted in many soil particles being thrown over the rim of the pit.

Laboratory Reactions. Several larvae were brought back to the laboratory and placed in individual glass containers that were three and one-half inches in diameter and two and one-half inches deep; these had been filled previously with fine soil and kept in the laboratory room that is maintained at a fairly constant temperature (26 plus or minus 2 degrees Centigrade). When the ant-lion was placed on the soil it soon buried itself beneath the surface by backward locomotion accompanied by downward flexing movements of its abdomen. After a time interval of five to thirty minutes, the digging would begin with the ant-lion moving backwards in a circular path, the tapered posterior tip of its abdomen functioning like a hand-plow and its head and mandibles as a scoop-shovel. The first circular path only approximates the outer boundary of the completed pit, the digging process tending to enlarge it as the larva circles downward. The path traveled by the insect until the completion of the pit can best be described as an inward and downward spiral. Ten out of eighty pits were partial; of these, two were completed later on and the remaining eight were not, but an examination of the remainder a week later showed that the larvae had pupated.

FACTORS GOVERNING THE SIZE OF THE PIT

Field Observations. When the larvae were dug out of the pits it was apparent that with few exceptions the size of the pit varied directly with the size of the ant-lion.

Laboratory Experiments. Twenty-one larvae were weighed, placed in individual containers and left undisturbed for a week. At the end of this time the diameters of the pits were recorded, the larvae removed and examined. Table I shows the results listed as diameter of the pit in millimeters and the weight of the larva in milligrams.

This table shows that the diameter of the pit is in direct proportion to the larval weight between the limits of 21 to 45 mm. It also indicates that any pits larger than this upper limit would contain larvae about to pupate or which have already pupated. Field observations made after this experiment was performed confirmed these conclusions.

TABLE I
RELATION OF PIT-DIAMETER TO LARVAL WEIGHT

Individual	Diameter	Weight	Individual	Diameter	Weight
A.....	21	5	L.....	33	22
B.....	21	5	M.....	33	24
C.....	22	5	N.....	40	33
D.....	22	7	O.....	43	30
E.....	24	9	P.....	48	48*
F.....	25	11	Q.....	49	55*
G.....	26	12	R.....	50	85*
H.....	28	13	S.....	53	63*
I.....	28	15	T.....	54	60*
J.....	29	17	U.....	55	55*
K.....	31	20			

*At the time of examination these individuals had pupated.

ECOLOGICAL FACTORS OF PIT-BUILDING

Field Observations. Most accounts state that pit-excavations occur after sundown, during twilight or darkness. Since the author had seen activity during the daytime, it occurred to him that pit-building may be a temperature rather than a light response. Temperature readings were taken in two habitats; Cantwell Cliffs, and Old Man's Cave. Table II lists temperatures and time of day at Cantwell Cliffs' habitat. Readings were taken at three levels of the habitat by placing one thermometer bulb one and one-half inches in the soil which was the usual depth of the ant-lions; a second thermometer was laid on the soil surface, and a third hung with its bulb twelve inches above the soil. The habitat was not exposed to direct sunlight.

TABLE II
TEMPERATURE READINGS OF CANTWELL CLIFFS' HABITAT

READING LEVEL	TIME OF DAY, JUNE 29, JUNE 30											
	1 p.m.	2 p.m.	3 p.m.	4 p.m.	7 p.m.	8 p.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	12 n.
Above soil.....	29 C.	26	27	29	25	24	20	20	22	24	26	28
Soil surface..	26 C.	25	25	26	25	23½	20½	21	22	23	23½	25½
Below surface..	23½	23½	23¼	24	23½	23	21	21	21½	22	22½	23

This table shows that air temperatures are the highest of the three habitat-levels and the variability the greatest. Temperatures on the soil surface are slightly lower and a lesser variability. Temperatures one and a half inches below the surface are the lowest and show the least variability, with only two and one-half degrees difference occurring between the highest and lowest temperatures. The drop in temperatures recorded at two and three P. M. was due to showers which

occurred between one-thirty and two-thirty. A month later temperature readings were taken at Old Man's Cave. While recording temperatures in the morning a far greater number of pits was observed occurring in the shade than in the light, so shade temperatures were taken as well beginning at nine A. M. Table III records these temperatures.

TABLE III
TEMPERATURES OF OLD MAN'S CAVE HABITAT

READING LEVEL	TIME OF DAY, JULY 29, JULY 30										
	9p.m.	10p.m.	11p.m.	1a.m.	3a.m.	5a.m.	7a.m.	9a.m.	11a.m.	1p.m.	5p.m.
Above soil.....	21½	20	19	19	18	18	20 Shade	36½ 27½	26 26	25½ 25½	26 25½
Soil surface.....	23	22½	22	21½	20½	20	23 Shade	50 26	33 25¼	30 25	27 25
Below surface.....	24	24	23½	23	22	21½	22 Shade	35 24	32 24	29 24	26 24

On the day these temperatures were read the ant-lion habitat was exposed to direct sunlight until nine o'clock. The extreme rises in temperature occurred in the two-hour interval between seven and nine in the morning. After this time the habitat was in the shade. Soil temperatures in the shade showed little variation, with a difference of five degrees on the surface and only two degrees beneath the surface. Soil temperatures in the sun, however, showed a variation of thirty degrees on the surface and thirteen beneath the surface. Since only a few of the pits occurred in the sun-lighted soil as contrasted to the shaded soil, perhaps the high temperatures exceeded the range of tolerance causing death or migration of the ant-lions to shaded soil.

Laboratory Reactions. To test the relationship between temperature and pit-building a thermal gradient was established in a sandbox. This box was about six feet long, a foot in height and width and constructed with wall board. The bottom was lined with copper sheeting, and in each end of the box a copper container twelve inches on a side was attached to this lining. Ice was kept in the one container and an electrical heating unit in the other. Two inches of white sand covered the bottom of the box. Temperature readings of the sand were taken by means of a thermocouple and a thermal gradient recorded between eleven and seventy-four degrees Centigrade. For example, readings taken every ten centimeters from cold to hot were as follows: 11, 18, 23, 25.3, 27.5, 29.5, 32, 36.5, 44, 55, and 74 degrees. In the *first* experiment twenty ant-lions were placed on sand at random throughout the length of the box to determine survival temperatures. They were examined one hour later and those found above 37 degrees were dead while all those in the sand including 37 and below were alive. In the *second* experiment ten larvae were placed on the sand with a temperature of 38.5 degrees and examined twenty-four hours later. Five of them were dead; four of these at the same location that they were placed and the other at 40 degrees. The remaining five had migrated to lower temperatures of 38, 31, 27, 24, and 23.75 degrees as determined by thermocouple measurements. Pits were built by the three at the lowest temperatures but the one at 27 was a partial pit. In the *third* experiment ten larvae were used, spacing them ten centimeters apart throughout the length of the box. Table IV lists the temperatures of the sand at those locations and the results obtained when examined three hours later.

TABLE IV
RELATION OF TEMPERATURE TO ACTIVITY

Temperature	Results	Temperature	Results
18.3	Partial pit	27.3	Migration to 29.6, no pit
22.0	Partial pit	36.0	Migration to 31.0, no pit
24.9	Pit at 24.8	39.4	Death
26.6	Pit at 26.7	43.2	Death
26.7	Pit at 26.7	50.5	Death

In the *fourth* series of observations a varied number of ant-lions were placed at random in the box as they were brought in the field from time to time. A total of thirty records are summarized in Table V, grouped according to the temperature range in which they were found about six hours after they had been placed on the sand.

TABLE V
RELATION OF TEMPERATURE TO PIT ACTIVITY

Temperature Range	Number of Larvae	Results
16-18.....	2	No pits
18-20.....	1	Small pit
20-22.....	2	Small pits
22-24.....	4	Pits
24-26.....	8	Pits
26-28.....	8	Pits
28-30.....	2	No pits
30-32.....	3	No pits

Although these experiments have involved small numbers and should be repeated, they do indicate that there is a definite relationship between temperature and pit building. Temperatures between 20 and 28 degrees are tolerated; small pits or none are built below this range; migration or death occurs above this range. They indicate that the building of pits after sundown is due to a temperature factor rather than light.

CONCLUSIONS

1. The retrograde circuitous method of pit building is established for this species. Any small or irregular pits found in the field are not caused by a different method, but rather by the presence of small larvae, interrupted activity, or incompleteness due to the onset of pupation.
2. The size of the pit varies directly with the size and weight of the larvae until a maximum diameter of 48 mm. and a maximum weight of 45 milligrams is reached. Any diameters or weights larger than the maximum indicate the presence of larvae about to pupate.
3. Pit building occurs only within a temperature range of 20 to 28 degrees; below this range little or no activity takes place; above this range migration occurs; temperatures above 38 degrees may result in the death of the larvae.
4. Field observations show that in direct sunlight soil temperatures may exceed the range of tolerance; this causes migration to either higher temperatures and death, or to lower temperatures and construction of another pit.

REFERENCES

- Turner, C. H. 1915. Notes on the behavior of the Ant-Lion. Biol. Bull., 29: 277.
 Wheeler, W. M. 1930. Demons of the dust. W. W. Norton and Co., New York.